



Digital illustration of the current state of bastion castle in Zheshev made by the author of the article, Olha Tikhonova.

Approach to comprehensive analysis of bastion castle ensemble with historic gardens: novel combined strategy

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Abstract: Bastion castle ensemble is a complex structure that belongs to defensive residences, which usually include the historic gardens and play an important role in the formation of the townscape. The two main structural components of such built complexes are palatial body and bastion fortifications. However, some bigger ensembles can also include other functional buildings. Due to the nature of the structure, namely the presence of defensive elements, which followed military development, many bastion castles underwent huge transformations. They were built and rebuilt because of the outdated design or destruction by the enemy. That is why studying such ensembles only from a historical perspective or analyzing only their fortification part is not enough to understand the whole complex, which is much more than a single-type building. In contrast, this paper proposes an interdisciplinary approach to studying bastion castles on the example of a bastion castle in Zheshov (Poland). Specifically, this paper uses a combined strategy that includes interpretative–historical and qualitative–computational strategies as a systematic and comprehensive approach to the research. This strategy consists of seven points of analysis: historical transformations, composition, situation, landscape, fortifications, typomorphology, and space syntax. This work represents a methodological framework that can be used for the analysis of any bastion castle ensemble in the world.

Keywords: bastion castle; interdisciplinary analysis; space syntax; typomorphological comparison; Zheshov.

1. Introduction

Researchers usually study bastion castles using historical description or geometrical analysis of fortifications despite bastion castle complexity. Due to the bastion castle structure, which consists of two main built parts - civil and military, some examples of this type can be found among palace studies, others among castles. Usually, those works are formed in the form of a catalog with several castles from the particular region with a short history, plan, and a photo (Adamczyk, 2004; Guerquin & Muszyński, 1984). Sometimes it can be a description of one castle with detailed history and transformations that it passed through the centuries (Barącz, 1865; Kryczyński, 1894). More rare researchers can find detailed information about rehabilitation methods made on the castles (Galindo Díaz & Peñalver Martínez, 2020) or the description of current conditions. Some works analyze the military part's proportions (Obradović & Mišić, 2014; Spallone, 2015, 2017). Several studies have shown the recognition of similar and distinctive patterns in the modern defensive architecture of the seventeenth century based on a visual morphologic comparison (Haviser, 2010; Jayasena & Floore, 2010).

However, we need to have a different approach for bastion castles, as it is not just a military structure, but it is a complex that combines two functions – residential and defensive and usually includes historical gardens with pavilions or other buildings, for example, churches, educational institutions, auxiliary and industrial buildings (Remeshylo- Rybchynska, 2007).

Therefore, the author proposes a comprehensive analysis of bastion castles within the combined strategy that includes interpretative - historical, and qualitative - computational strategies as a systematic approach to the research. To demonstrate the application of the proposed method for analysis of bastion castle, the author of this paper chose Zheshov bastion castle in Poland as a case study.

2. Research Aim

This study aims to define the interdisciplinary approach to the comprehensive analysis of bastion castles to understand the building and conduct further adaptation works.

3. Method

The study proposes to analyze the defensive residences using an interdisciplinary approach, namely combining the following aspects:

1. A historical transformation of a case study to have enough contextual understanding of its final appearance, phases of building, and rebuilding.
2. A compositional analysis to define how the parts of the bastion castle connected to the whole.
3. An analysis of the castle situation in the landscape based on the cadastre maps and their descriptions.
4. An analysis of the gardens as a part of the bastion castle complex in the landscape.
5. An analysis of the fortification system strength.
6. An analysis of the similarities with other European examples and theoretical models (typomorphological comparison)
7. Space syntax analysis of pedestrian circulation, lighting, and ventilation.

3.1 Historical transformations of the main shape

The first point, *Historic transformations*, brings into view the information on the case from the past. It answers essential questions about which modifications the building passed over the years.

3.2 Compositional analysis

This tactic aims to show an approach to the compositional analysis of bastion castles' structure as an architectural form. This part of the method is based on the principles for building analysis, well-described in schemes by Ching in his research (2007). His main findings, suitable for bastion castle analysis, are briefly reviewed and reassessed for application here.

The analysis of the castle composition as a freestanding structure can be considered from four different angles. The first angle of research can be a part of any other four. It is based on the ordering principles described in (Ching, 2007: 339). Namely, they are **axis**, **hierarchy**, **rhythm**, and **transformation**. The second is a comprehensive view of the castle complex as one element (organism) to find the relation of indoor spaces (closed private spaces) to outdoor spaces (open-air environment, which enclosed on the top with a sky). The third angle concerns just rooms of the castle (residential areas) and their organization in the space of castle outline (in our case, organization inside of fortification wall). The fourth is the analysis of visual connections in the space by looking through the openings, connecting the inner space with the landscape.

Concerning the second, third, and fourth angles of analysis, Ching examined several archetypal forms. His results mainly focused on two structures, which are helpful in our research: courtyards and pavilions. Courtyards resemble the traditional building spatial types, which are derived from Italian town halls. In this type, the building volume defines the space, representing the introverted scheme of the relation of form and space. Another type is when a wall encloses the pavilion. It represents a residential corpus enclosed by a wall or several linked buildings with different functions surrounded by a wall. This type can be divided into two subtypes: when the house is connected to the wall and when the house is a freestanding building within the enclosed space.

From Ching's analysis of the clustered organization of volumes in space, the method of this paper proposes to use three cases, which are suitable for bastion castles' analysis. They are the following clustered organizations as (Ching, 2007: 222):

- clustered about an entry (type "a"),
- centralized organization (type "b"),
- volumes contained within the enclosed space (type "c").

In the case of the bastion castle analysis, the organization type "c" is always present. It corresponds to one or several residential buildings placed in limited by bastion fortifications space. A centralized composition "b" is a stable organization comprising several spaces grouped around a dominant, central space. Usually, the dominant space in bastion castles is a regular geometric figure, which aligns secondary spaces along its perimeter. The secondary spaces can be equal in form, size, and function, which will allow creating a regular symmetric organization; otherwise, those spaces can have different shapes, possibly adapted to the site configuration. In clustered about an entry organization (type "a"), buildings are grouped and placed on different entry sides. However, in most cases with bastion castles analysis, the researcher will encounter combined organizations. They can be as follows: clustered buildings within the entry inside of limited space ("a+c") or a centralized pattern within a specified outline ("b+c").

3.3 The castle situation in the landscape

The suitable source for castle situation analysis is the historical cadastre maps (Tikhonova, 2016). One of the best sources in Europe to study military architecture, including bastion castles, are the maps of the military surveys of the Habsburg Empire made between 1764-1869 (Timár, 2009). As those maps were produced with particular attention to

the position of military items, they are helpful in the study of military architecture. For the case study presented in this paper, the author chooses the Map of the Kingdom of Galicia and Lodomeria, a part of cadastre maps, which Officer Friedrich von Mieg made during the First Military Survey during 1764-1783 (Tikhonova, 2016). These maps help establish bastion castles' position in specific regions and analyze the historical townscape's surrounding environment and compositional relations.

3.4 Gardens as a part of the bastion castle complex in landscape

Remeshylo-Rybchynska (2007) pointed out the importance of gardens in the historically formed landscape of the noble residential complexes in the 17th-18th century when she studied the main components of such complexes.

3.6 The fortification system

The fortification system strength is an essential element in bastion castle analysis as it talks about its military value. However, not all bastion castles were built for safety purposes. Some of them were made just as a symbol of power, on the stream of a popular trend without eminent necessity in the military component in the residence of the noblemen. Hence, we need to know the fortification system value (purpose), which will help the architect decide on the fortification rehabilitation methods.

3.7 Typomorphological comparison

Typomorphology is used as a part of the method because it combines the study of typology and morphology, which are complementary fields of analysis necessary to understand a complex form. The term typology comes from the Latin word *typus*, which means picture, figure, or model (Epp, 1987: 104, 107), when morphology comes from the Greek word *morphos*, which means 'shape' (Steadman, 1983).

Webster defines 'type' as something which exhibits distinctive traits, as in a model or pattern, and to which others are viewed as linked and from which they may be derived, either practically or conceptually (Epp, 1987:105).

During the 18th century, Quatremere de Quincy developed the concept of type as a theoretical reference, clearly differentiating between type and model. He claimed that the model has precisely identifiable characteristics and lacks the correct semantic significance associated with the concept of type (Jacoby, 2015: 14).

3.7 Space syntax analysis

The term “space syntax” refers to a set of approaches for establishing mathematical measures of plan design underlying its spatial structure rather than its physical dimensions (Hillier & Hanson, 1984). This method converts a design into a mathematical graph, which is then analyzed to disclose different aspects of the plan underlying its spatial structure.

The Space Patterns software (Suter, 2015) was chosen for the present paper because it was tested and explicitly adopted to analyze bastion castles during the author’s close cooperation with its developer. It is the only software with an automatically generated multi-view space analysis and is a user-friendly web application. Another benefit of using this system is the possibility of comparing the results with other bastion castles, which are freely available in the database. However, currently, there are just seven reference projects with bastion castles in the system, limiting the comparison quality. The comparison quality is expected to improve when the number of reference projects in the database increase.

The analysis is done in two steps. The first step is to model interior spaces volumes connected by the door volume in CAD system and upload the prepared model on the website. The second step is automatically calculating the metrics and graph creation on top of the model by Web-application Space Patterns. This system generates heat map-style visualizations for several types of analysis, among which interesting for us are accessibility (pedestrian circulation view), lighting (daylight access), and ventilation. A network-based space layout represents each visualization. In addition, the system provides local and global metrics as a result of each visualization (Olha Tikhonova, 2021). When computing a result for a particular node or the entire graph, local metrics show the qualities of a single node inside the graph, whereas global accounts for the features of the whole network (Dawes Ostwald, & Lee, 2021; Suter, 2015).

A space access network called Pedestrian circulation in the system helps the researcher to answer such questions as what are the distances and number of spaces which the person needs to pass to get to the farthest room, how many cycles (alternative roads) are in the building, what is the accessibility (centrality) of particular space in the plan. The darkening of the color in visualization represents the distancing of the space further away from the entrance.

The daylighting of spaces represents the evaluation of access to daylight, showing the spaces with direct natural light access, indirect light access via other adjacent spaces, and spaces without light. The light-transmitting

spaces considered in the analysis are windows, openings, glass doors.

The natural ventilation shows the lengths of internal air circulation paths. In this view, the air transmitting spaces considered are the following: operable windows, doors, and openings. Besides the space metrics with distances, edges, and cycles, we can see the colored visualization from a lighter color to a darker color that shows the high, medium, and low natural ventilation potential of spaces.

4. Application of the Method

4.1 History of restoration and transformations of Zheshov bastion castle

On June 26, 1842, the fire burnt the castle’s roof with the copula of the chapel and spire of the tower. After that event, the destroyed tower was lowered; the copulas of the chapel were not rebuilt. In 1895, the Austrian authorities commissioned the reconstruction of the damaged castle to Zygmunt Hendel. Until 1897, he measured the castle and made research and several concepts of the adaptation project (Janczykowski, 2015: 70). Existing archival documents with Hendel’s several proposals of castle reconstruction allow the assumption that the architect tried to find a compromise between the requirements of investors, demanding a significant increase in the usable cubature of the castle, and the architect’s desire to preserve the authenticity of the monument. From the beginning, he assumed the necessity of rebuilding the upper stories of the gate tower together with a decorative Baroque spire, taking a drawing of Wiedemann as a basis for the reconstruction project. In the first version of the project, he proposed a superstructure of one story above the three wings of the building, leaving in the original height in the middle parts of the west wing with the reconstructed tower (see Fig. 1A) and the plan (see Fig. 1B).

As shown in Fig. 1A, Zygmunt Hendel eliminated the platform next to the sides of the tower, which was as high as the ground floor, and placed windows on the front façade on the ground level corresponding with the rhythm of the windows on the first floor. He preserved an old projecting cornice along the top of the building to separate the raised level of the wings from the original part (Fig. 1A, Fig. 2). In addition, Zygmunt Hendel underlines the width of the side wings on the front façade using rustication. In such a way, he divided the elevation into three principal parts (two in the corners and one in the middle) and two background planes between them. He kept the rusticated arcades in the western wing on the inner façade in the courtyard (Fig. 2).

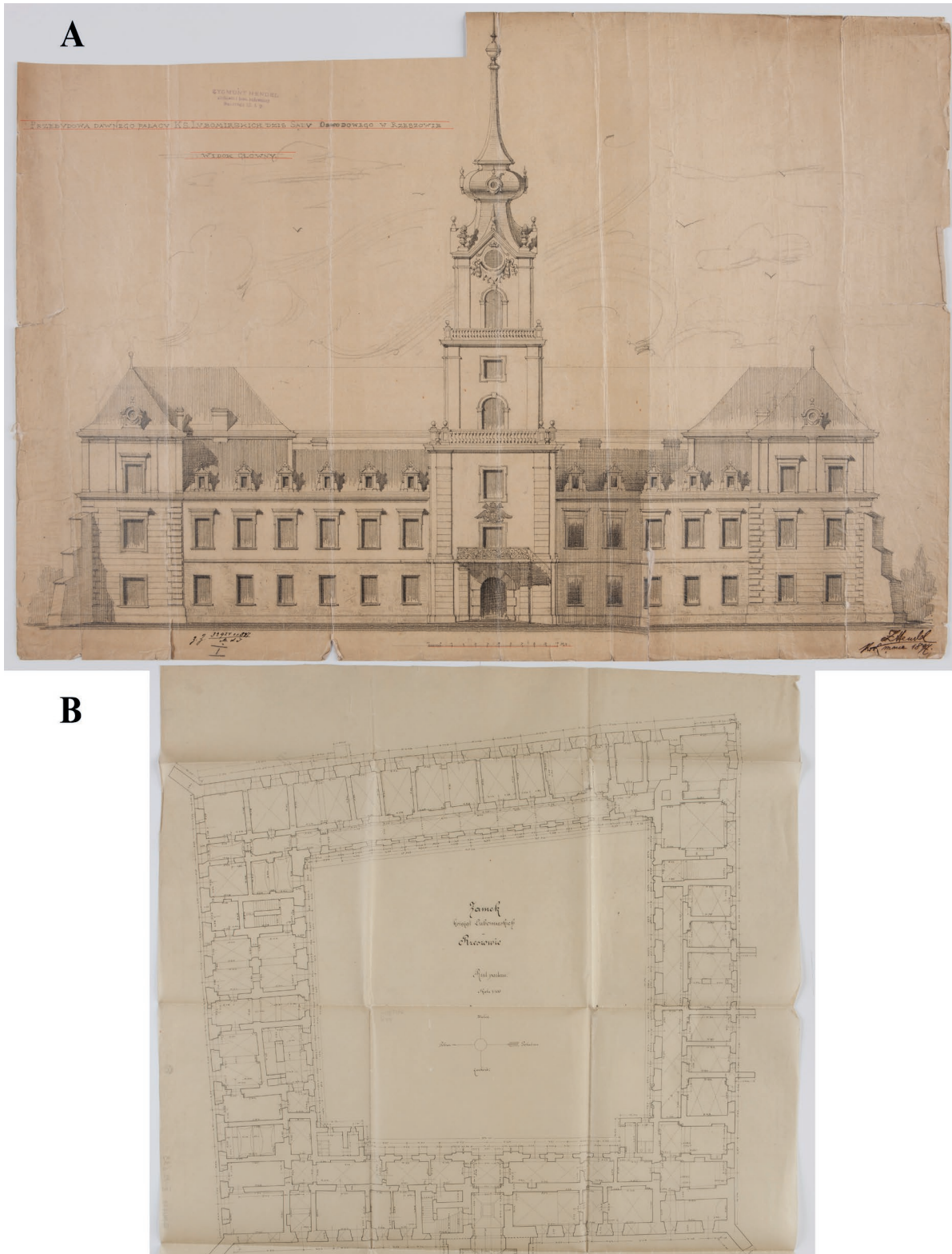


Figure 1 | **A** The elevation of the adaptation project for Zheshev castle made by Zygmunt Hendel in 1897 (Source: Photo made by Andrzej Chęć on 14/01/2012. Title: Zygmunt Hendel, Rzeszów - Zamek Lubomirskich - Widok główny, 1897, 55.8 x 80 cm, papier, kalka, nr inw. MNK III-PL-628. © Collection of Muzeum Narodowego w Krakowie). **B** Ground plan of the palace part of the adaptation project in Zheshev bastion castle made by Zygmunt Hendel in 1897 (Source: photo made by Andrzej Chęć on 14/01/2012. Title: Zygmunt Hendel, Rzeszów - Zamek Lubomirskich - Plan parteru, 1897 rok, 89.6 x 84.5 cm, tusz, papier, nr inw. MNK III-PL-633. © Collection of Muzeum Narodowego w Krakowie).



Figure 2 | Side and inner (from courtyard) elevation of the adaptation project for Zheshov castle made by Zygmunt Hendel in 1897 (Source: photo made by Andrzej Chęć on 14/01/2012. Title: Zygmunt Hendel, Rzeszów - Zamek Lubomirskich - Przebudowa dawnego Pałacu ks. Lubomirskich: „Fasada podworca”, 17,8 x 35,5 cm, kalka, nr inw. MNK III-PL-636/2. © Collection of Muzeum Narodowego w Krakowie).

Based on the fact that there was a second variant of the project with a more significant gross floor area (total amount of floor space in a building), we can conclude that the first variant had insufficient additional usable space. In the second version of the project, Hendel provided the entire building with a new story and created extra usable space in an attic on the mansard roof (Fig. 3). In addition, in this version, Hendel reconstructed the chapel's dome, placed in the original location, but one floor higher (we can see it on the right corner of Fig. 3). Unfortunately, this

project has not been implemented either. The administration decided to demolish the old structure except for the tower and constructed a new one resembling the old monument.

The new, three-story building with a high roof was designed on a rectangular plan, with one avant-corp in the inner courtyard, located behind the gate tower, where staircases and toilets were placed. According to researcher Janczykowski (2015, p. 70), the new castle



Figure 3 | The second version of the main front elevation for adaptation project for Zeshov castle made by Zygmunt Hendel in 1897 (Source: photo made by Andrzej Chęć on 14/01/2012. Title: Zygmunt Hendel, Rzeszów - Zamek Lubomirskich - Przystosowanie zamku do celów sądownictwa (plany z roku 1897) - Fasada zachodnia, 52 x 51.7 cm, farba, papier, nr inw. MNK III-PL-644.© Collection of Muzeum Narodowego w Krakowie).

project is entirely the work of architect Franciszek Skowron. Comparing the current state Fig. 4 with Fig. 3, we can notice that Franciszek Skowron used the elements of previous drawings by Zygmunt Hendel, both in the upper stories and the tower gate, as in the details of the decor. However, the scale and form of his reconstruction project do not show much connection with the original

bastion castle; the only element referring to its shape is the tower and general compositional organization type.

As we can notice from comparing the ground plan of Hendel (Fig. 1 B) and the author's simplified plan model based on the 20th-century inventory drawings from the archive in Zeshov (Fig. 8), the ground plan footprint is



Figure 4 | The current state of front elevation (Source: author's illustration based on the photo made on February 20, 2018).

different nowadays. The original structure had a trapezoid plan with the wing parallel to the fortifications. In contrast, the new design has a pure rectangular footprint. Fortunately, the remaining bastion fortifications remained authentic, although they were deformed due to the liquidation of the earth's breastworks and the introduction of low parapets in place of breastworks (2015).

4.2 A compositional analysis

After analyzing historical changes in Zheshov bastion castle, the most appropriate for our analysis is the theoretical reconstruction of the castle structure in the 17th century made by Pilarczyk (Pilarczyk, 1997: 306) confirmed by the research work made by Zygmunt Hendel in 1897. As we can see from the castle's history, it had several different stages of development with various forms. The current structure of the residential corpus is new; compositionally, it does not connect to the fortification outline. On

the other hand, although it was not regular, the previous design was very harmonic, as it included already existing buildings. Moreover, chosen plan for analysis underlines the best authentic cultural townscape relations.

In the 17th century, the castle represented a massive integrated structure, where the courtyard was enclosed by residential corpus, which was placed on the fortification platform with bastions (Fig. 5). Although the castle base is a trapezoid, which center does not perfectly match the circumcentre of the circumcircle around the fortification outline, the compositional organization has a centralized pattern. In this centralized pattern, the trapezoid base of the fortification contains a smaller trapezoid parallel to the outline of fortifications. This smaller trapezoid represents a residential corpus containing a scaled smaller trapezoid of the inner courtyard.

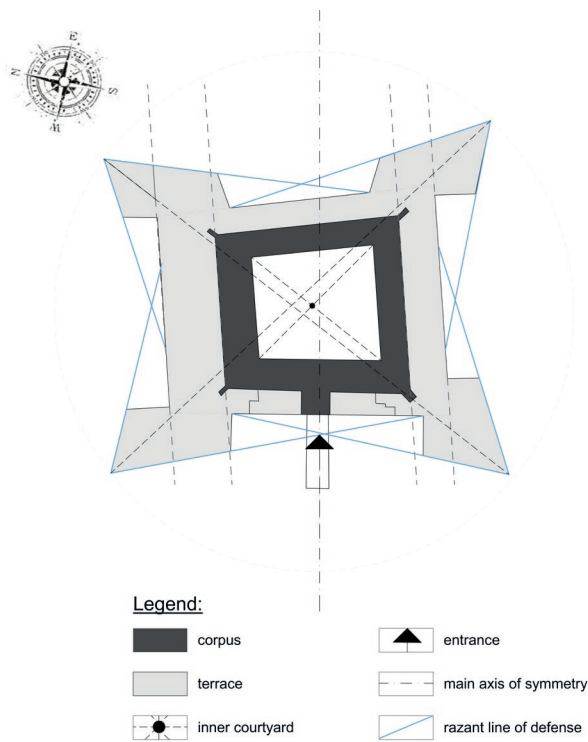


Figure 5 | Compositional analysis of Zheshov castle. Centralized organization. Integrated structure (Source: author's work based on theoretical reconstruction made by Pilarczyk).

The central axis that goes from east to west towards the entrance organizes the castle into two parts (right and left). As far as we can judge from Fig. 1, this axis organized the façade symmetrical into two equal parts. A tower in the middle of the main façade, which projects out of the main body, and two massive bastions on the corners of each side of the platform underline this symmetry.

Based on the previously discussed types, a castle in Zheshov combines all three types "a+b+c." The series of rooms are organized about the entry tower (type "a"), making a loop with the courtyard inside, which makes the composition centralized (type "b"). This loop of rooms located on the platform is surrounded by bastion fortifications (type "c").

4.3 The castle situation in the landscape

The first modern appearance of the settlement was formed before 1637, during the times when the city belonged to Mikotałaj Spytek Ligęza (Książek, 1988: 173). At that time, the main elements were the castle and the summer palace constructed on the south of the city's medieval linear part. The summer palace became a linking point between the

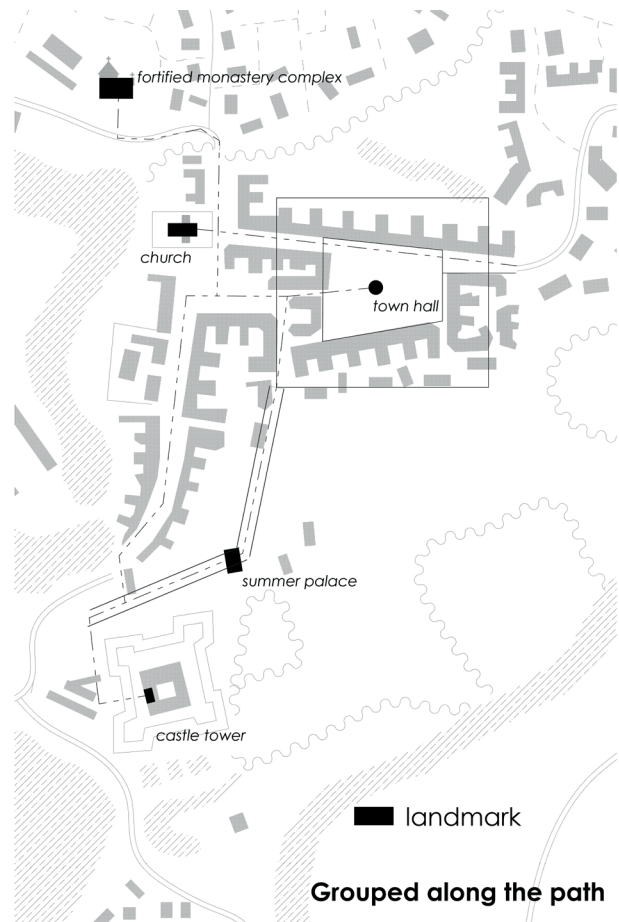


Figure 6 | Clustered organization along the path. Zheshov castle in the city structure (Source: author's illustration based on a city plan made on the First Military Survey in the 18th century, stored in Vienna Kriegsarchiv under the ref. BIXa.390 (Section 100 #18)).

bastion castle and a primitively fortified new Renaissance core (with earthen ramparts and wooden palisade). The axis that connects a castle and an old linear city is finished by the fortified monastery complex of Bernardine (Fig. 6). According to Olha Tikhonova's classification (2017), the typological structure of the relation of Zheshov castle to the city is Type I - Castle with open Renaissance city, although the Renaissance part had some primitive defensive structure around the core.

The placement of the monastery in the Zheshov ensemble underlines the importance of spiritual wealth as in Palladian villas, namely Barbaro Maser and villa Rotonda complexes. Besides the spiritual belongings of the owner, the sacral buildings like churches and monastery complexes were a way to influence and shape the political views of the believers and a state (Książek, 1988: 183).

4.4 Gardens as a part of the bastion castle complex in landscape

The castle in Zheshov has a strong visual connection with a landscape all around the castle, which underlines its centric composition in the landscape and visual relation with the summer palace (Fig. 7). According to a fragment of the topographical map with the bastion castle, palace, and gardens in Zheshov made by N. Wiedemann from 1762, there was a garden between the palace and the castle.



Figure 7 | View from the bastioned platform of Zheshov castle towards the summer house (marked in red). (Source: Author's photo made on 20th February 2018).

Such conjugation of the castle with summer palace and gardens is a fascinating example of an organization in Poland and resembles two similar cases in Italy, villa Caprarola with barchetto and Palazzina of Forte di Belvedere with Palazzo Pitti.

4.5 The fortification system

The military value of the castle had a beneficial effect even in the hands of the first owner Mikołaj Spytek Ligęza. According to Ryszard Rogiński, Zheshov castle withstood the Tatars attack in 1624 (1990: 87). Many cannons can also prove the military importance of the castle, which shows the inventory made in 1738 according to a document in Zheshov Archive (Unit 519, Call # 1255).

4.6 Typomorphological comparison

The similar composition of an integrated centralized organization of fortified structure with dominating residential corpus with courtyard we can see in the already mentioned example of villa Caprarola finished by architect Giacomo Barozzi da Vignola, the first design of Verneuil made by

Jacques Androuet du Cerceau, or Jacques Perret's fortified palaces models (1610).

The four wings' pavilions of the residential corpus, which enclose the courtyard with multiple similar spaces connected in the enfilade way in Zheshov castle, derived their roots from North Italian town halls or central - Italian palace type, such as Palazzo Medici. We can also find a similar urban palace based on a rectangular plan with a courtyard in France, especially in the south part of France. According to researcher Rosenfeld (1996: 58), one of the earliest palaces of this type is the palace of the archbishops of Avignon, made by the Cardinal Arnaud de Via in the 14th century. However, the primary idea comes from the rectangular-shaped Roman *quaestoria*, which consisted of a series of rooms enclosing the central courtyard (Johnson, 1984: 104).

4.7 Space syntax analysis

The outcomes of the automatically performed spatial analysis (see Fig. 8) of pedestrian circulation in Zheshov bastion castle plan of the current state are as follows:

- The space access network has 14 cycles (8 belong to the tower structure, which can be combined in different ways).
- The tower part creates a symmetrical graph.
- Maximum depth from the unit door (nearest): 82 levels (edges) or 42 spaces, which characterize the planning structure as extremely deep.
- There are two access points to the building: one from outside and one from the courtyard.
- The building has a corridor planning system as it was in the initial plan in (Fig. 1B).
- The most connected space is a hallway that belongs to the tower structure.
- The large spread of distances to unit doors (diverse distance color variation in spaces and graph).
- Max. distance to the unit door is 183.53 m, which is characterized as a very long distance.

The automatically performed analysis of natural lighting (see Fig. 9) shows:

- 82% of spaces with direct daylight and 13% of spaces without daylight which means that the building has very high daylight sufficiency.

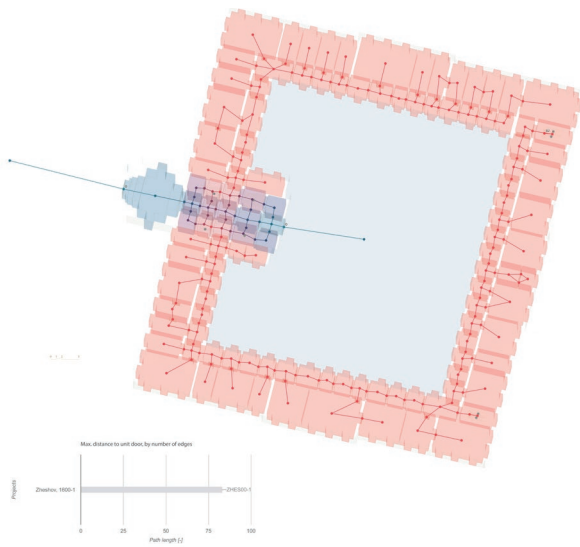


Figure 8 | Space Syntax analysis – Pedestrian Circulation View (Source: figure made by author using web application Space Patterns).

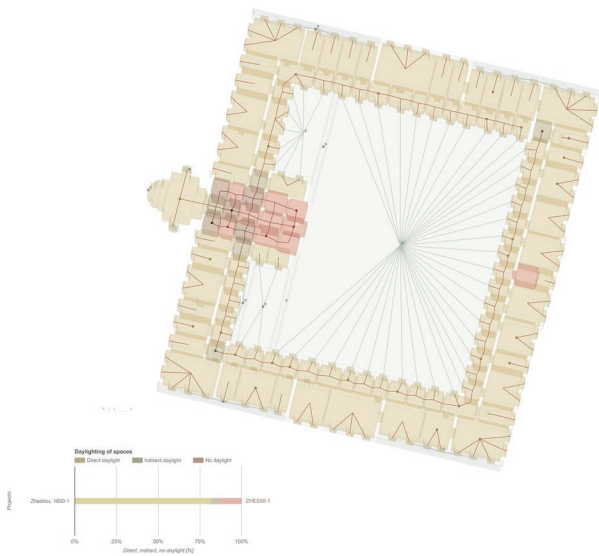


Figure 9 | Space Syntax analysis – Natural Lighting View (Source: figure made by author using web application Space Patterns).

- bilateral spaces on the outer corners of the building and in the tower.
- the building has a big inner courtyard with corridor windows towards it.

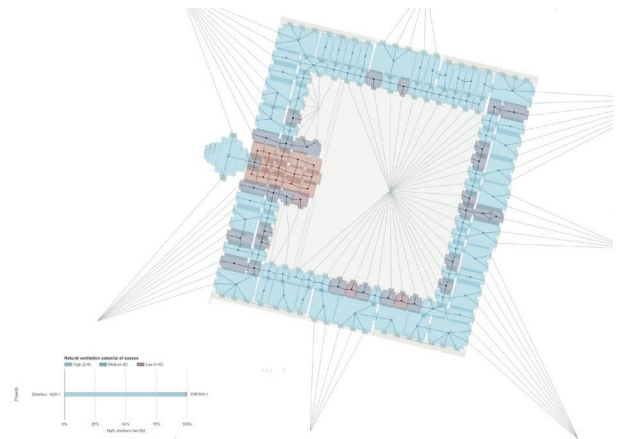


Figure 10 | Space Syntax analysis – Natural Ventilation View (Source: figure made by author using web application Space Patterns).

The automatically performed natural ventilation analysis (see Fig. 10) showed that more than 75% of the space has high ventilation potential. The first example of defensive residence, which integrated those principles using the design with enclosed yard, which provides sufficient daylight and ventilation for spaces, was villa Porto-Colleoni in Thiene, according to Tavernor (1991: 29).

5. Conclusions and discussion

As in the Renaissance period, the noble residence, even in unstable political times, should reflect the beauty and power of an owner. At the same time, it should be comfortable and well-designed. These principles induced changes in the residential spaces for civil buildings, including defensive residences such as bastion castles. Moreover, these trends provoke the changes in each part of the whole bastion complex that consists of a house, a defensive enceinte, and a garden, at the same time making a strong relationship with the landscape, transforming the townscape into one unit. A comprehensive interdisciplinary analysis that evaluates each principal component of the bastion ensemble proposed here helps understand the bastion castle phenomena from different angles and creates a solid knowledge about the case study. Such an approach can become a methodology for examining bastion castles in other countries, especially in Italy, which has a rich number of those structures.

The proposed method, as a result, gives a deep understanding of bastion castle features and their importance. Moreover, such a complex method of analysis can be

used for the preparation of documents for inclusion of such military monuments to UNESCO World Heritage list or developing the rehabilitation plan as it shows not only the main characteristics of the bastion castle but also the bastion castle relation to other important buildings in the landscape, its placement in the cultural townscape, which is one of the necessary features of the authenticity value of the monument as said in (Olha Tikhonova & Alho, 2015).

Acknowledgments

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